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RESULTS OF 1/4 SCALE RADIOACTIVE FILTER TRANSPORTATION PACKAGE MODEL 9 m DROP TESTS

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OHRD Report No 87-182-K

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ABSTRACT

This report contains a record of the 1/4 scale Radioactive Filter Transportation Package (RFTP) drop test program including test observations and experimental results. The drop tests were designed to assess a variety of preliminary design concepts under the 9 meter test condition usually employed for licencing of Type B(U) containers. The results were also to be used for computer bench marking purposes.

The drop tests were conducted on the 26th and 27th of May 1987 at Chalk River Nuclear Laboratories. All experimental data recorded by the technical staff of Chalk River was conveyed to Ontario Hydro through Report # C1-VIBR-86 (Appendix A of this report).

job	file	date	report no.
21-136-462	825.94	January 14, 1988	87-182-K

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EXECUTIVE SUMMARY

RESULTS OF 1/4 SCALE RADIOACTIVE FILTER TRANSPORTATION PACKAGE MODEL 9 m DROP TESTS

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This report documents a series of 9m drop tests performed on two 1/4 scale models of the Radioactive Filter Transportation Package (RFTP). The report, contains a description of the RFTP models and the various drop orientations, a detailed discussion of the instrumentation on each model and all the recorded and observed experimental data.

The RFTP will be designed to safely transport radioactive ion exchange fuel filters and replace the Super Tiger Transportation Package. The drop tests were designed to assess a variety of preliminary design concepts under 9 meter drop conditions. Each model was subjected to two drops in different orientations. The drop orientations were such that the top corner, bottom corner, bottom and side of the models were the initial impact points during the drop tests. The models were instrumented with strain gauges and accelerometers and the data was recorded by the staff of Chalk River Nuclear Laboratories, where the tests were conducted.

It was found that on the top corner and flat side drop test all but one or two bolts of the overpack lid broke off. The surviving bolts were always closest to the point of impact. The polyurethane foam endcaps which covered the fuel filter payload were also damaged during each drop test. The damage, however, was insignificant since they were designed to be damaged to protect the payload.

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job	file	date	report no.
21-136-462	825.94	January 14, 1988	87-182-K

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To Mr. H.N. Isaac
Nuclear Materials
Design & Development - Generation

RESULTS OF 1/4 SCALE RADIOACTIVE FILTER TRANSPORTATION PACKAGE MODEL 9 m DROP TESTS

1.0 INTRODUCTION

This report describes the results of a series of 9 m drop tests performed on two 1/4 scale models of a preliminary design of the Radioactive Filter Transportation Package (RFTP). The final design of this package will be designed for the safe transportation of radioactive Ion Exchange Fuel Filters and to replace the Super Tiger Transportation Package.

The 9 meter drop test is one of a series of tests required for the licencing of Type B(U) containers. It is designed to show the structural integrity of containers under severe impacts and, therefore, was chosen as a reasonable test to evaluate some new proposed design ideas.

2.0 DESCRIPTION OF MODELS

The RFTP models are slightly modified 1/4 scale replicas of the preliminary design of the full-scale transportation packages. They consisted of an inner and outer stainless steel can, welded together at their tops by a ring and two bolting flanges. The volume formed between the two cans was then filled with polyurethane foam having a density of approximately 320 kg/m^3 (see Figure 1).

A metal cylindrical filter flask payload, modelling the instation shielded Ion Exchange Fuel Filter flask, sat inside the inner can and was held in place by two foam endcaps. The foam endcaps were made of the same polyurethane foam used between the two cans. Containment of the payload and endcaps was achieved by a containment lid, secured in position by 12 stainless steel bolts. To provide additional protection to this area, an overpack lid was secured over the containment lid. The overpack lid consisted of a disk of polyurethane foam sheathed in sheet metal and held in place by 12 stainless steel bolts.

The assembled models stood 686 mm tall, 520 mm in diameter and had a mass of 222 kg including payload. The payload itself was 200 mm in diameter, 445 mm tall and had a mass of 90.7 kg. The steel used in the construction of the models was entirely stainless steel type 304 and 304L. The polyurethane foam between the two cans and inside the overpack lid was poured through two pouring ports located on the bottom of each model and through a single port on the top of the overpack lids.

For additional design details of the RFTP, please refer to the manufacturing drawings found in Report No. B87-53-K.

3.0 TEST DESCRIPTION

The two RFTP models were designated as models A and B. Each model was dropped twice from a height of 9 m in different orientations as shown in Figure 2. Model A was first subjected to a Bottom Corner drop followed by a Flat Side drop.

Model B was subjected to a Flat Bottom drop followed by a Top Corner drop.

To minimize the effects of the unscaled pouring ports, the models were always dropped such that the impact points were 90° away from any of the ports. The models were also dropped so that their centre of gravity was always inline with the point of impact. After each drop the models were opened up and all damage was recorded. All damaged components (bolts and endcaps) were then replaced prior to subsequent drops.

High speed photography and video were used with the intent of permanently recording each drop test.

3.1 Instrumentation

Both models were instrumented with strain gages and accelerometers to obtain deformation and deceleration data for each drop test. Figures 3 and 4 show the location of strain gages and accelerometer mounts for each model. Accelerometer mounts at locations A1, A2 and A3 on both models were identical. Details of these mounts are shown in Figure 5.

On model A, S1 and S2 are uni-axial strain gages. They are installed in the vertical direction on the inside of the inner can, approximately 12 mm above the bottom, 180° apart and 90° away from accelerometer mounts A1 and A2. Strain gages S3 and S4 are bi-axial rosettes and were installed on the underside of the containment lid approximately 6 mm away from the stiffening ring as shown in Figure 3. These gages were installed to measure strain at those locations during the drop tests.

On model B, S1,S2, S3 and S4 are uni-axial strain gages. They were installed in the vertical direction on the inside of the inner can approximately 12 mm above the bottom and 90° apart, such that gages S2 and S4 were in-line with accelerometer mounts A1 and A2. Strain gage S5 is a tri-axial rosette and was also installed on the underside of the containment lid in the centre as shown in Figure 4. Strain gages S6 and S7 are bi-axial rosettes and were also installed on the underside of the containment lid, approximately 6 mm away from the stiffening ring as shown in Figure 4. These gages were installed to measure strain at those locations during the drop tests.

Accelerometer mounts A1, A2 and A3 on both models have various accelerometer mounting positions. During each drop test, the accelerometers were mounted such that their most sensitive measuring axis were in-line with the drop.

These accelerometers were installed to measure deceleration data of the models and payload during the drop tests.

4.0 EXPERIMENTAL RESULTS

All four drops were accomplished successfully. Signals from strain gages and accelerometers were recorded on an instrumentation tape recorder. A video movie and high speed film were also used to record all drop tests. Still photography was used to capture damages to the model and its components after each drop test. Prior to each drop test, the inner lid bolts were tightened to 3.390 N.m torque. Torques were measured while removing these bolts after the test and are shown in Table 1. Results from strain gages and accelerometers are included in the AECL report in Appendix A. Photographs of the models after the drop tests are included in Appendix B.

Actual deformation data analysis of model A, after the Bottom Corner drop test, was performed to facilitate comparison with the analytical deformation data. The actual deformation data are shown in Figure 6.

The following observations were made during and after each drop test:

- Bottom Corner drop test (Pages 30 to 31)

  The drop impacted on its bottom corner as intended. Bolts on both lids were intact. Both endcaps were damaged during the test. The damage, however, was insignificant since they were designed to be damaged to protect the payload. Peak overpack and payload decelerations were measured as 361 g's and 335 g's respectively.

- Flat Side drop test (Pages 32 to 34)

  The model was steady during the fall and landed evenly on its side. All but two bolts from the overpack lid got broken off with ends flush to the top of the bolting flange. Both survived bolts were nearest to the impact point. Both endcaps were damaged. Peak overpack and payload decelerations were 495 and 391 g's respectively.

- Flat Bottom drop test (Pages 35 to 36)

  The model dropped square on its bottom and then rolled over into the nearby, approximately 1.5 m deep, hole filled with sand and stones. One bolt from the overpack lid and one eye-bolt broke off. Again both endcaps were damaged and peak overpack and payload decelerations were measured as 1000 and 391 g's respectively.

- Top Corner drop test (Pages 37 to 39)

  All but one bolt from the overpack lid were broken with ends flush with the top of the flange surface. Again the surviving bolt was located adjacent to the impact point. The top endcap was damaged but the bottom one was intact. Peak overpack and payload decelerations were measured as 402 and 363 g's respectively.

ACKNOWLEDGEMENTS

The drop tests were conducted at Chalk River Nuclear Laboratories (CRNL). All the experimental data was recorded by the staff of CRNL. Extensive technical assistance was also received from NMMD staff throughout the project.

The authors acknowledge and thank them for their assistance.

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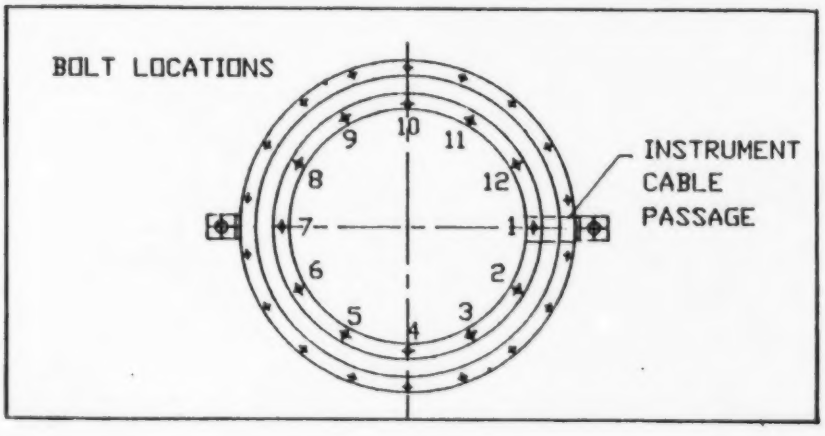
NNS/RZ:ko/msf

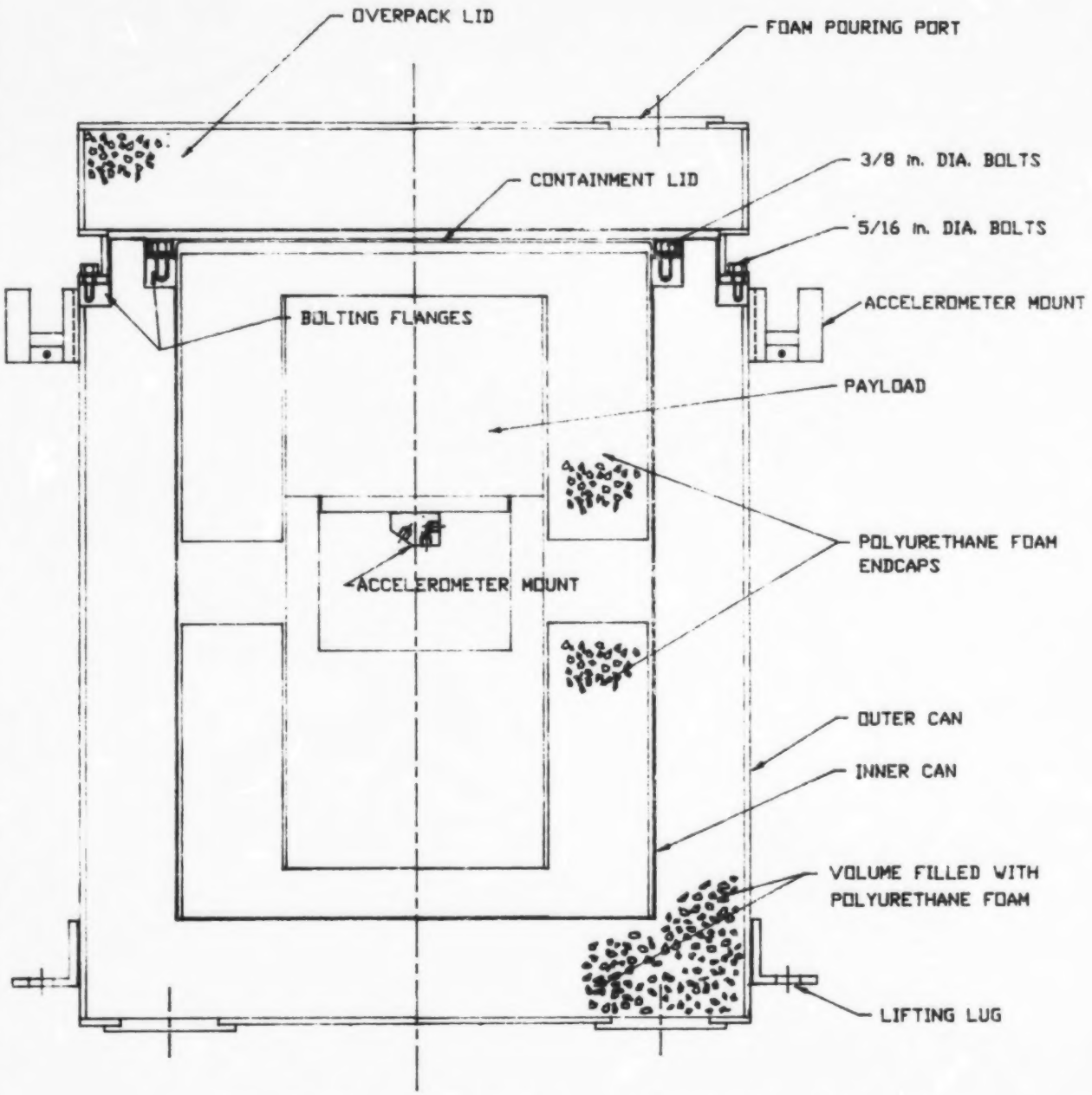
TABLE 1

CONTAINMENT LID TORQUE DATA

BOLT NO.	BOTTOM CORNER DROP TEST (N.m)	FLAT SIDE DROP TEST (N.m)	FLAT BOTTOM DROP TEST (N.m)	TOP CORNER DROP TEST (N.m)
1	1.695	0.226	0.565	8.474
2	1.695	0.452	0.565	2.825
3	1.808	0.339	1.356	9.265
4	2.034	0.565	1.921	2.599
5	2.712	1.582	1.243	11.637
6	1.469	1.8081	1.243	1.695
7	1.469	1.582	1.017	6.214
8	2.599	0.565	0.000	0.904
9	0.678	0.791	0.395	11.298
10	0.339	8.474	0.565	8.474
11	1.356	0.339	0.565	2.825
12	1.243	0.565	0.565	2.260

Note: The underlined data indicate location of impact.
Pre-drop bolt torques were all 3.390 N.m





CROSS-SECTIONAL VIEW OF THE

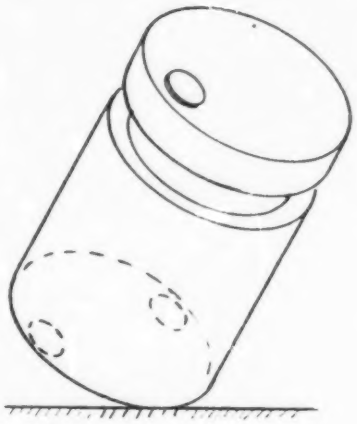
RADIOACTIVE FILTER TRANSPORTATION PACKAGE

FIGURE 1

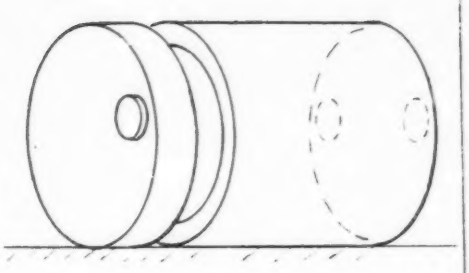
DROP 1

DROP 2

MODEL A

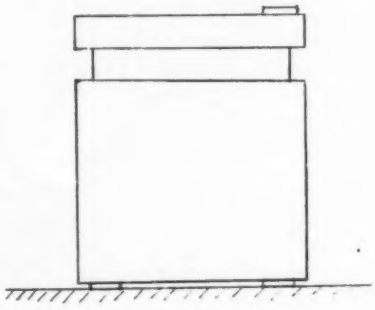


BOTTOM CORNER DROP

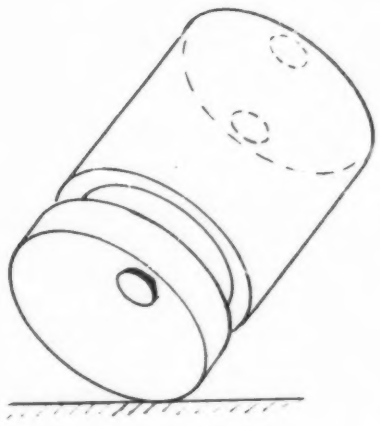


FLAT SIDE DROP

MODEL B



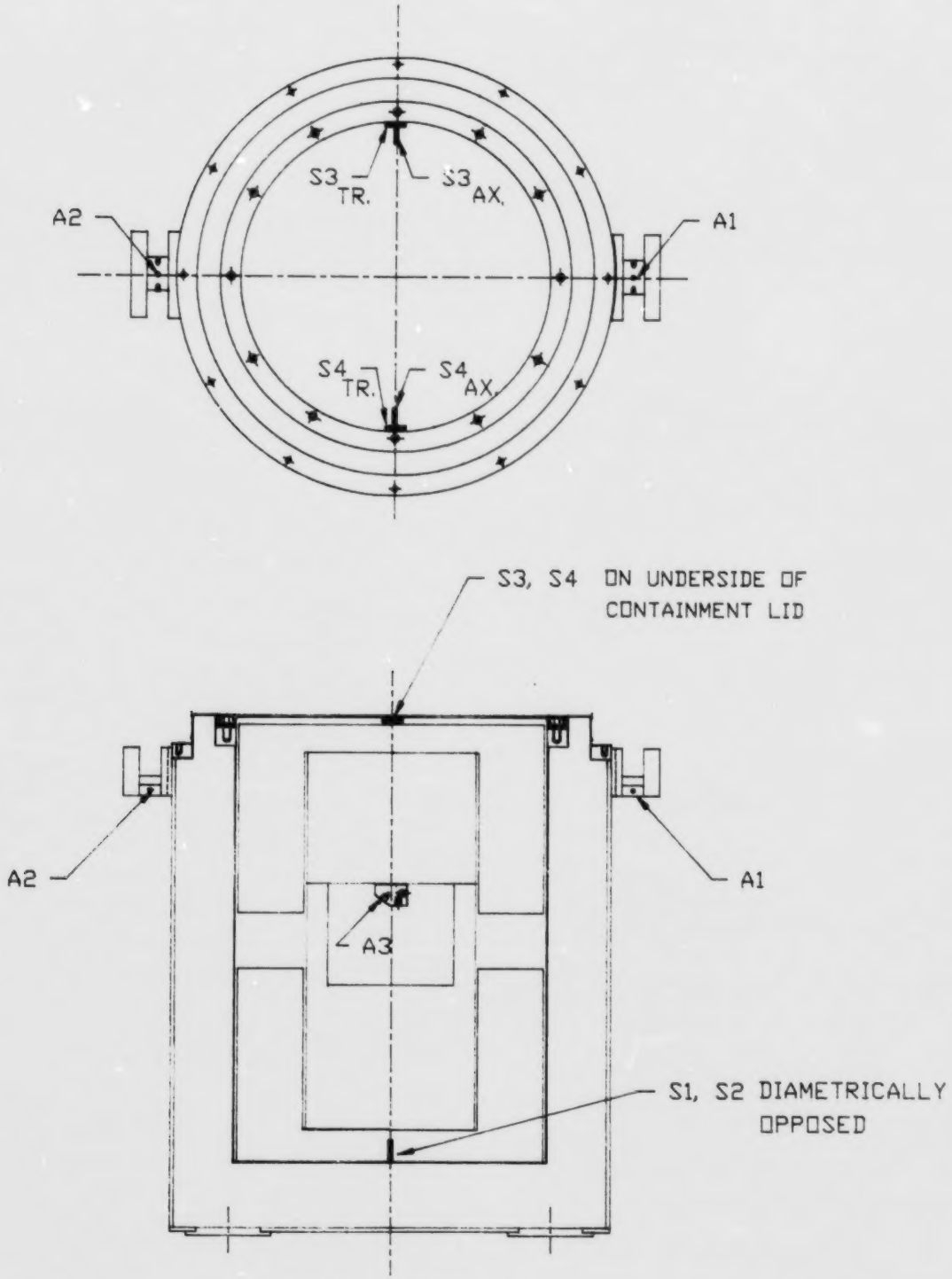
FLAT BOTTOM DROP



TOP CORNER DROP

DROP ORIENTATIONS

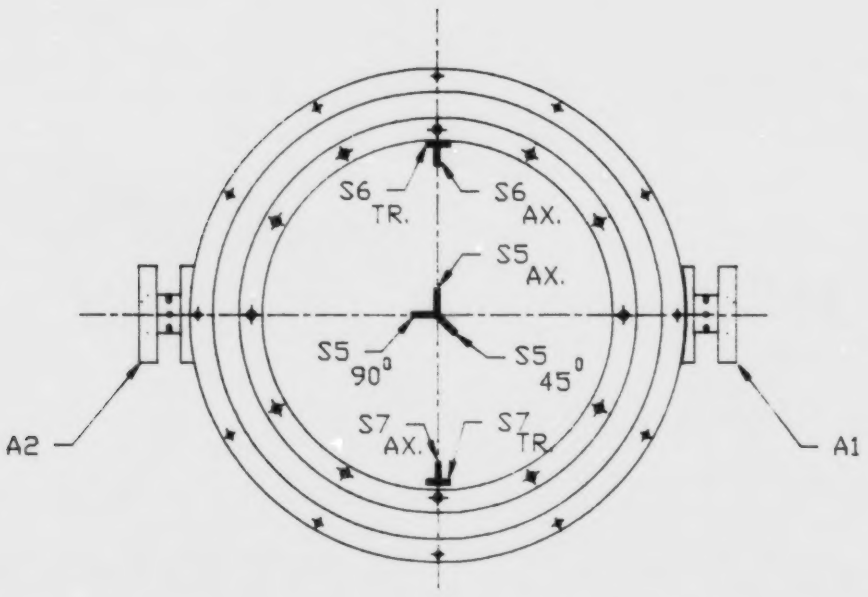
FIGURE 2



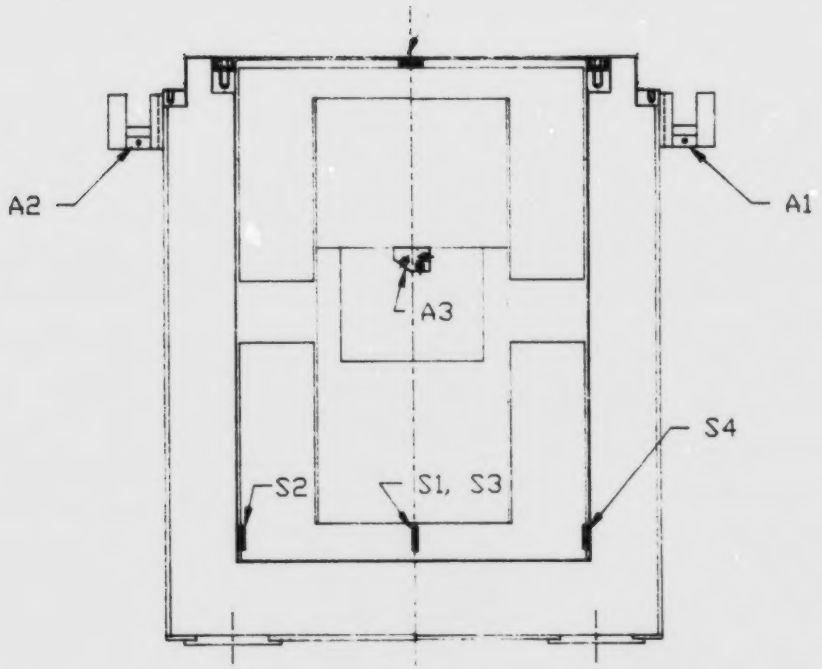
INSTRUMENT LAYOUT

MODEL A

FIGURE 3



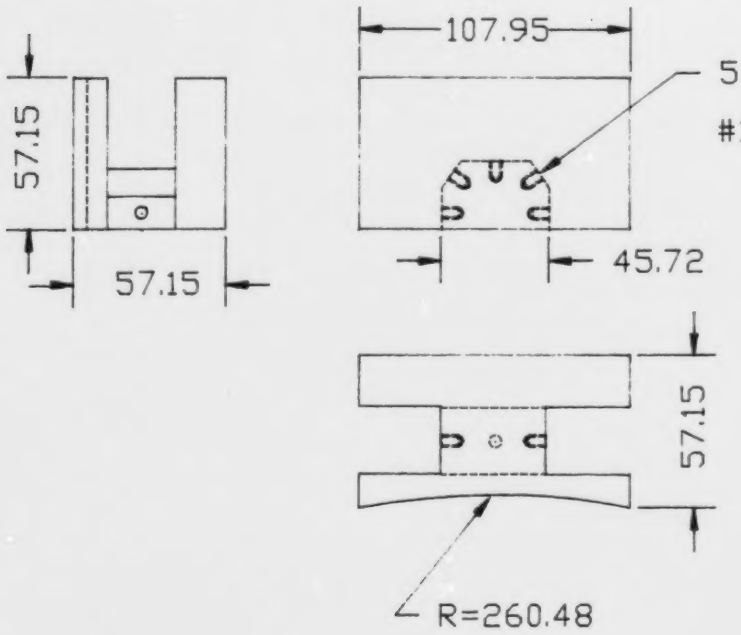
S5, S6, S7 ACROSS THE DIA. ON UNDERSIDE OF CONTAINMENT LID



INSTRUMENT LAYOUT

MODEL B

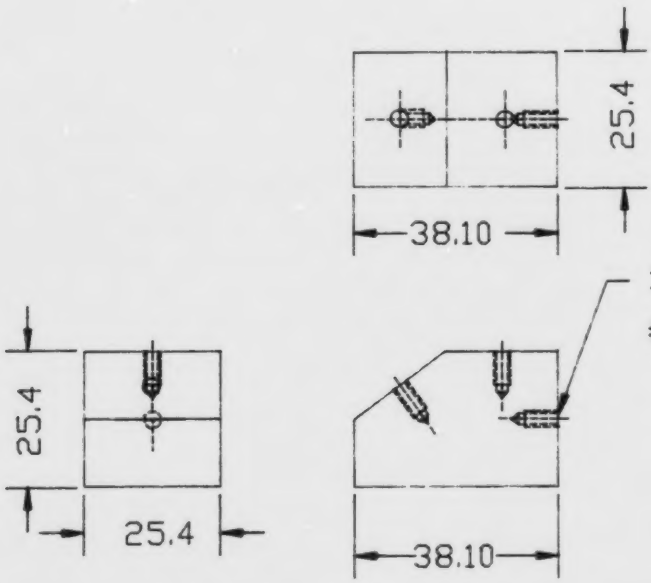
FIGURE 4



BODY MOUNT
(A1, A2)

NOTE:

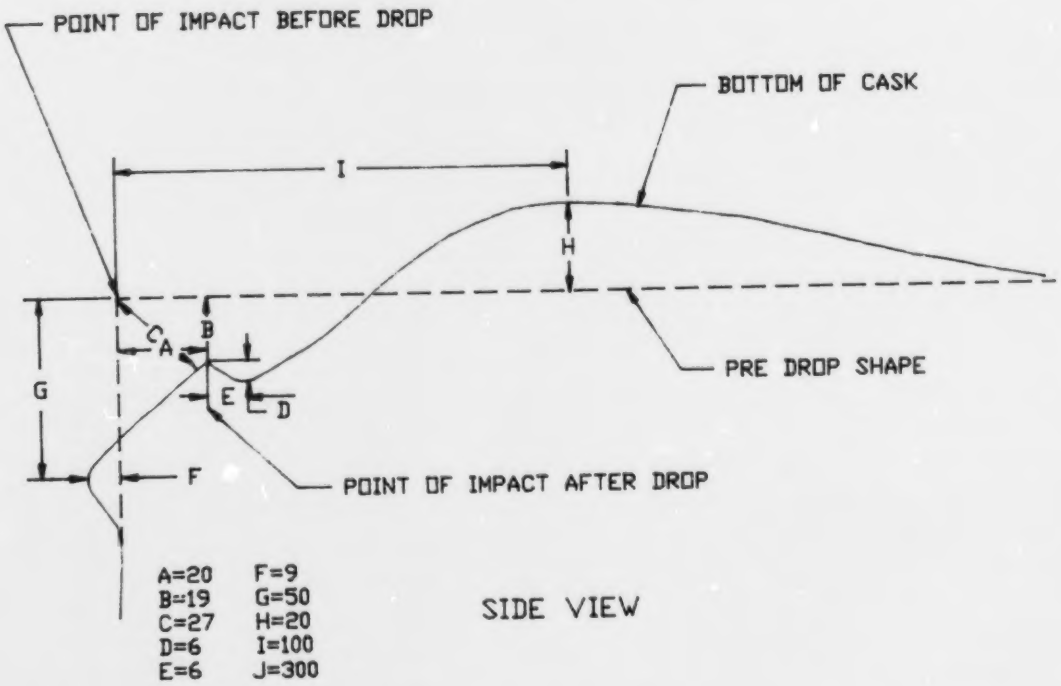
ALL DIMENSIONS IN MM

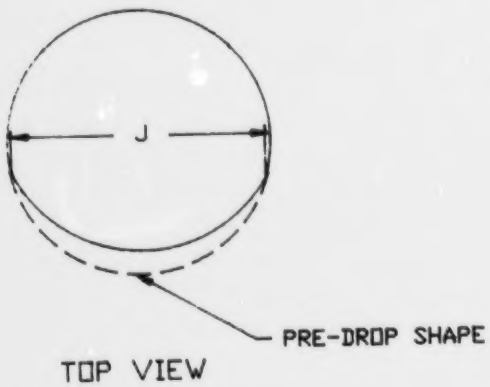


PAYLOAD MOUNT
(A3)

ACCELEROMETER MOUNTS

FIGURE 5





MODEL A DEFORMATION DATA AFTER BOTTOM CORNER DROP TEST

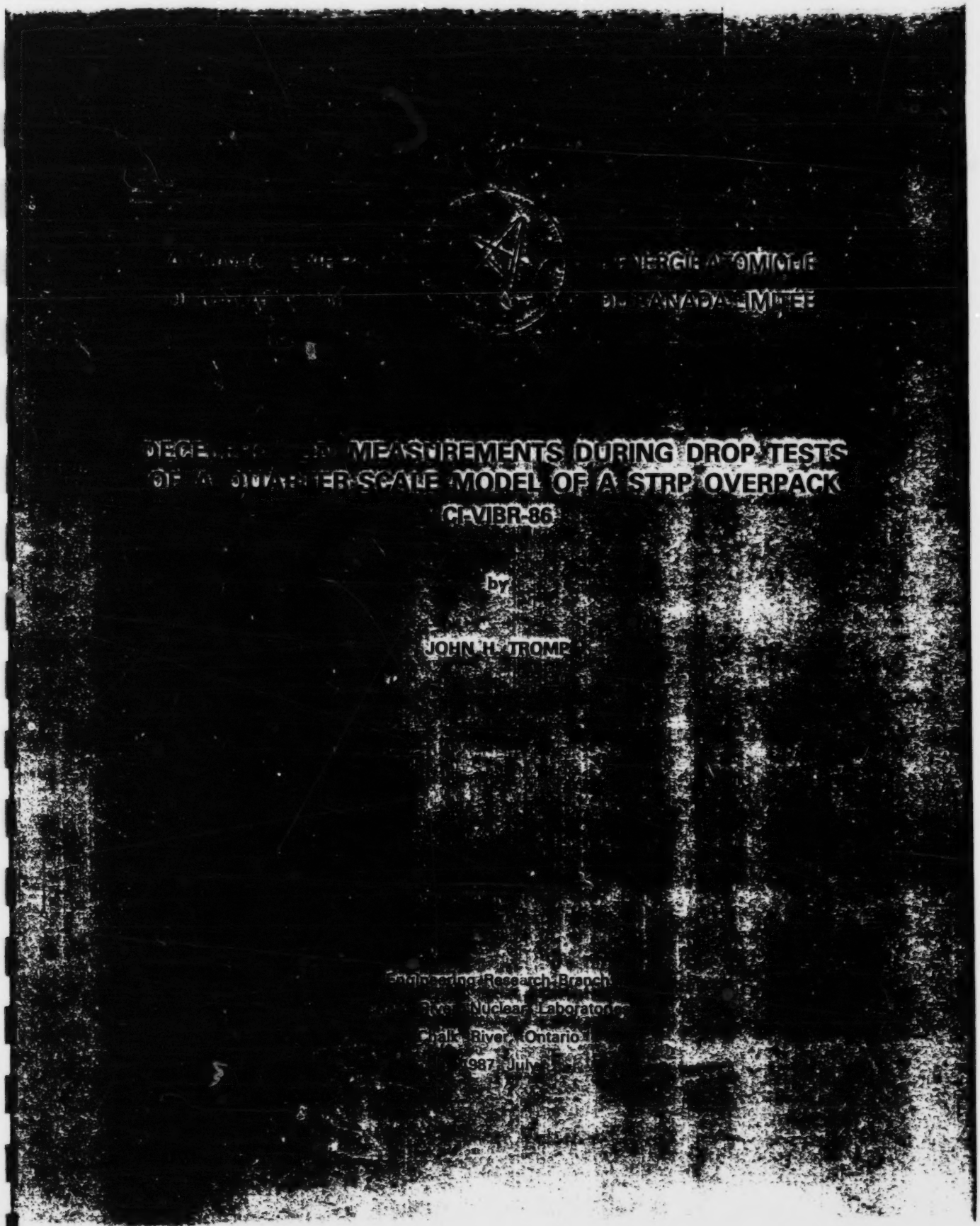
FIGURE 6

APPENDIX A

Atomic Energy of Canada Limited

Report Titled

"Deceleration Measurements During
Drop Tests of Quater-Scale Model
of A STRP Overpack"


ATOMIC ENERGY OF CANADA LIMITED
MEASUREMENTS DURING DROP TESTS
OF A QUARTER-SCALE MODEL OF A STRP OVERPACK
CI-VIBR-86
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ATOMIC ENERGY OF CANADA LIMITED

TECHNICAL MEMORANDUM

SUBJECT: Deceleration Measurements During Drop Tests of a Quarter-Scale Model of a STRP Overpack

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Abstract

Results of shock impact tests carried out for Ontario Hydro on a 1/4 scale model STRP overpack.

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1987 July

Deceleration Measurements During Drop Tests of a Quarter Scale Model of a STRP Overpack

1. INTRODUCTION

Impact tests were conducted on a quarter-scale model of Ontario Hydro's Super Tiger Replacement Package (STRP) Overpack. Engineering Research was asked to gather data during the impact of this overpack to verify the soundness of the pack design. All drops were performed from 9.0 metres onto an unyielding surface using two models (A&B) and different overpack orientation (see Figure 1).

2. INSTRUMENTATION

The overpack and payload were instrumented with low impedance accelerometers, capable of measuring 2500 g and withstanding a shock load of 5000 g. As well as accelerometers, the overpacks were also instrumented with strain gauges installed by Ontario Hydro. Deceleration and strain signals were stored on a multi-channel tape recorder for later analysis. Figures 2 and 3 show the location of the accelerometer and strain gauges. All accelerometer positions were changed to line up with the direction of the drop.

3. TEST RESULTS

The signals stored on tape contain both the deceleration frequency and all natural frequencies of all parts of the package and contents excited on impact. Natural frequencies are usually higher frequencies having higher amplitudes and should therefore be filtered out to reveal the true deceleration frequency.

Figures 4 to 9 show the signals after they have been filtered so that anything above 2000 Hz is eliminated. Tables 1 to 4 are a summary of the deceleration data from Figures 4 to 9.

4. COMMENTS

During the initial drop, the payload inside the overpack moved around enough to cause severe damage to some of the strain gauge leads inside. Unfortunately, some leads pulled away from the gauge making it inoperatable. Had enough time been allowed, some of these gauges could have been reconnected prior to the second drop. The same problem exists with accelerometer leads, however, they are much easier to replace.

5. CONCLUSION

The four drops carried out on the two overpacks have been described and the results obtained. The results are tabulated in Tables 1 to 4, and shown on Figures 4 to 9.

TABLE 1

DROP TEST #1-"A" (FILTERED 2000 Hz) BOTTOM CORNER:

TRANSDUCER NO.	NO. OF DIV.	mV/DIV	VOLTS	ATTENUATION	SENSITIVITY mV/g	g's	STRAIN με	
1308	-12	50	-0.60		1.790	-335		
1305	+13	50	+0.65		1.799	+361		
1302	+ 7	10	+0.07	10	1.991	+350		
S1 -	-	-	-	-	-	-		FAULTY
S2	-20	50	-1.0	10	435 με/v		-4348	
S3 axial	-14	50	*~~-0.9~~ -0.7	10	"		*~~-3913~~	-3045
S3 trans.	-11	10	0.11	10	"		- 478	
S4 axial	-11	50	0.55	10	"		-2391	
S4 trans.	-14	10	0.14	10	"		- 608	

* As per Erratum issued by AECL.

TABLE 2

DROP TEST #2-"A" (FILTERED 2000 Hz) SIDE:

TRANSDUCER NO.	NO. OF DIV.	mV/DIV	VOLTS	ATTENUATION	SENSITIVITY mV/g	g's	STRAIN με	
1308	14	50	0.70	1	1.790	391		
1302	19	50	0.95	1	1.991	477		
1305	16	50	0.80	1	1.799	445		
S1	-	-	-	-	-	-		FAULTY
S2	-	-	-	-	-	-		FAULTY
S3 axial	-11	50	0.55	10	435 με/v		-2391	
S3 trans.	+16	5	0.08	10	"		348	
S4 axial	- 6	50	0.30	10	"		-1300	
S4 trans.	+13	5	0.065	10	"		283	

TABLE 3

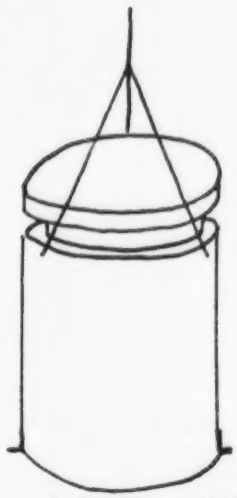
DROP TEST #1-"B" (FILTERED 2000 Hz) FLAT BOTTOM DROP:

TRANSDUCER NO.	NO. OF DIV.	mV/DIV	VOLTS	ATTENUATION	SENSITIVITY mV/g	g's	STRAIN με	
1308	-14	50	-0.70		1.790	- 391		
1305	-18	100	-1.80		1.799	-1000		
1302	- 7	100	-0.70		1.991	- 351		
S1	+15	20	0.30	10	435 με/v		1304	
S2	-25	20	-0.50	10	"		-2174	
S3	-24	20	-0.48	10	"		-2087	
S4	+11	20	0.22	10	"		957	
S5-45°	+18	50	0.90	10	"		3913	
S5-90°	+18	50	0.90	10	"		3913	
S5-axial	+18	50	0.90	10	"		3913	
S6-axial	-17	50	-0.85	10	"		-3696	
S6-trans.	-24	20	-0.48	10	"		-2087	
S7-axial	-26	50	-1.30	10	"		-5652	FAULTY
S7-trans.	-19	20	-0.38	10	"		-1652	

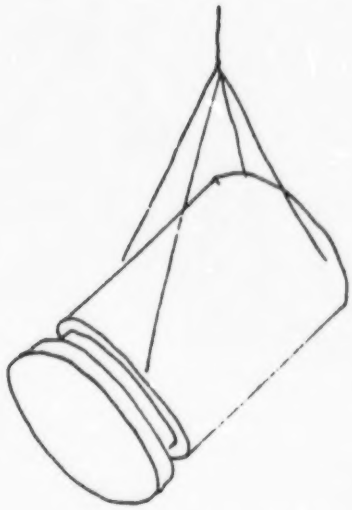
TABLE 4

DROP TEST #2-"B" (FILTERED 2000 Hz) TOP CORNER:

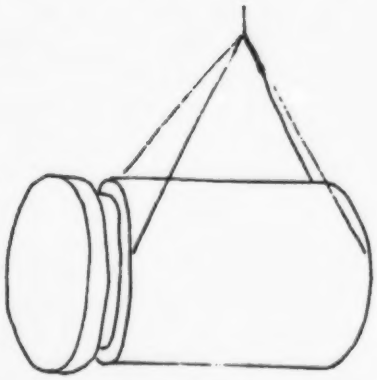
TRANSDUCER NO.	NO. OF DIV.	mV/DIV	VOLTS	ATTENUATION	SENSITIVITY mV/g	g's	STRAIN με
1308	+13	50	0.65		1.790	-363	
1305	-14	50	-0.70		1.799	-389	
1302	-16	50	-0.80		1.991	-402	
S1	- 5	50	-0.25	10	435 με/v		-1087
S2	-19	10	-0.19	10	"		- 826
S3	- 3	10	-0.03	10	"		- 130
S4					"		FAULTY
S5-45°	- 5	50	-0.25	10			-1087
S5-90°	-	-	-	-	-	-	FAULTY
S5-axial	-	-	-	-	-	-	FAULTY
S6-axial	-	-	-	-	-	-	FAULTY
S6-trans.	-	-	-	-	-	-	FAULTY
S7-axial	-	-	-	-	-	-	FAULTY
S7-trans.	-	-	-	-	-	-	FAULTY



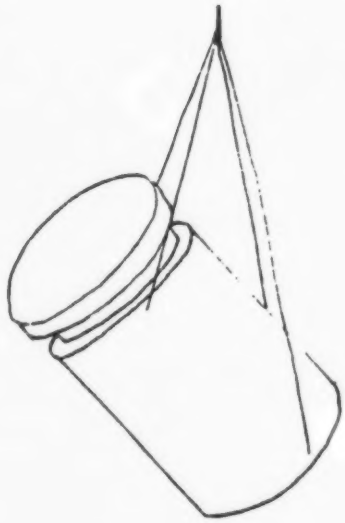
1st DROP - Model "B"
Flat Bottom



2nd DROP - Model "B"
Top Corner



2nd DROP - Model "A"
Flat Side



1st DROP - Model "A"
Bottom Corner

FIGURE 1: Drop Orientation of Models A&B Overpacks
Drop Height 9 m

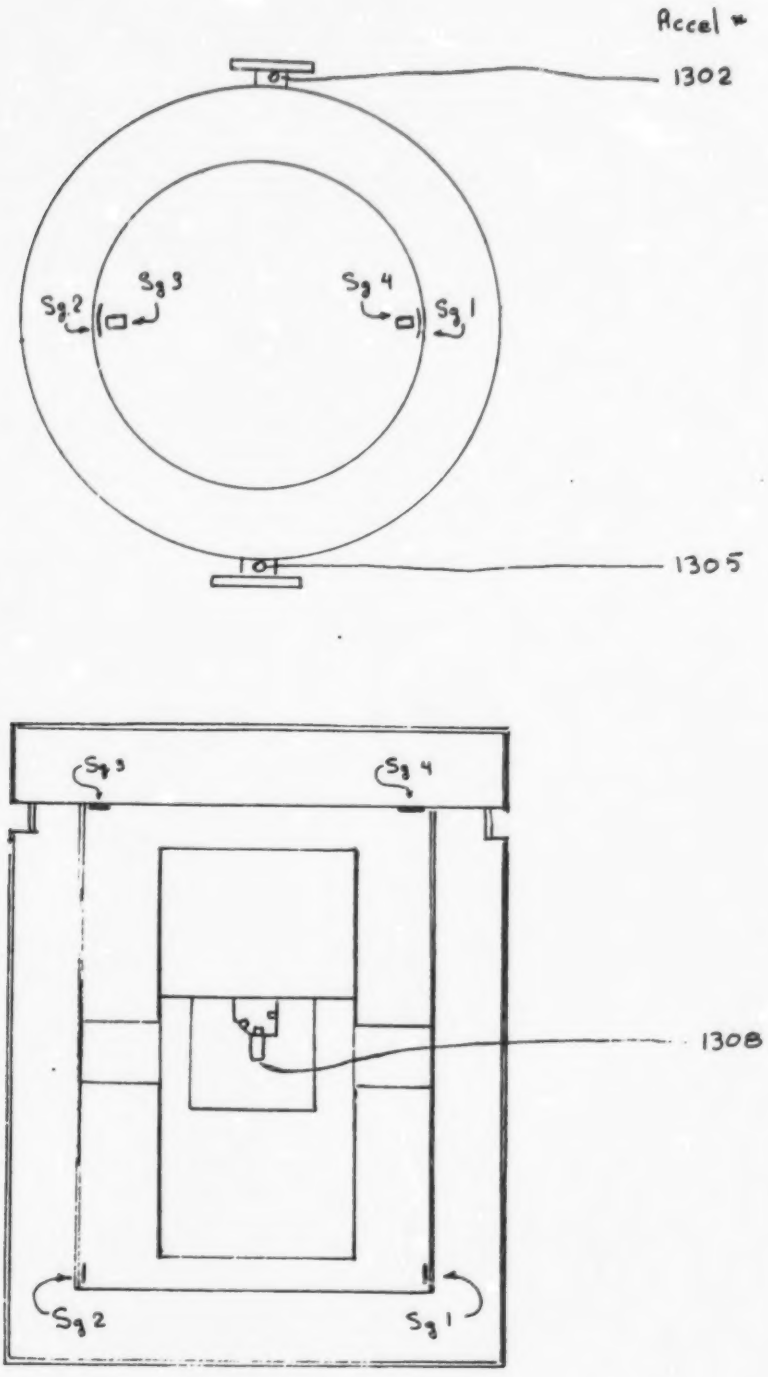
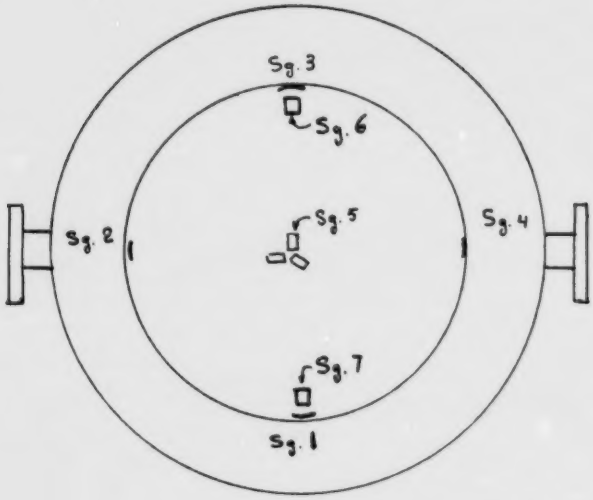


FIGURE 2: Overpack Model "A" Instrument Placement



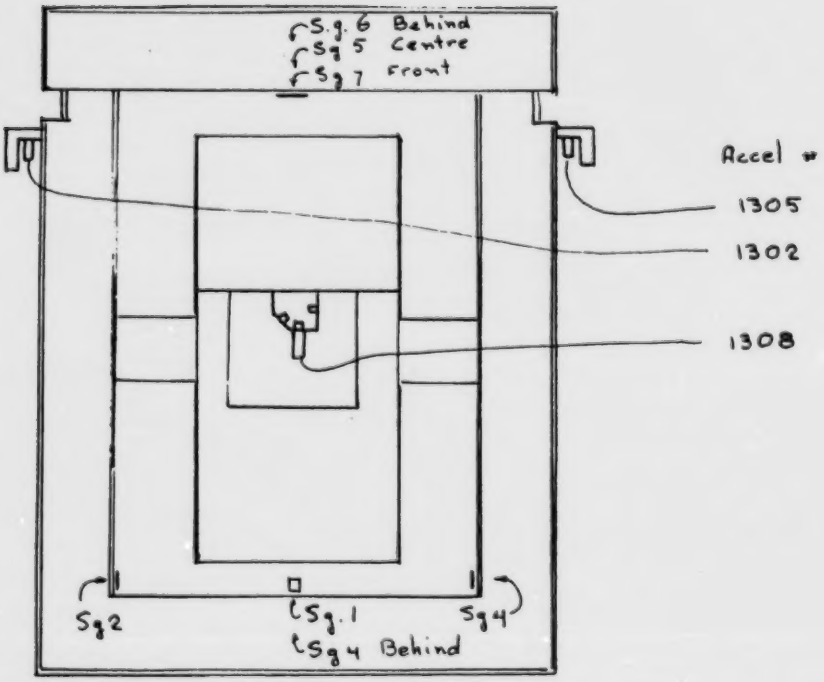


FIGURE 3: Overpack Model "B" Instrument Placement

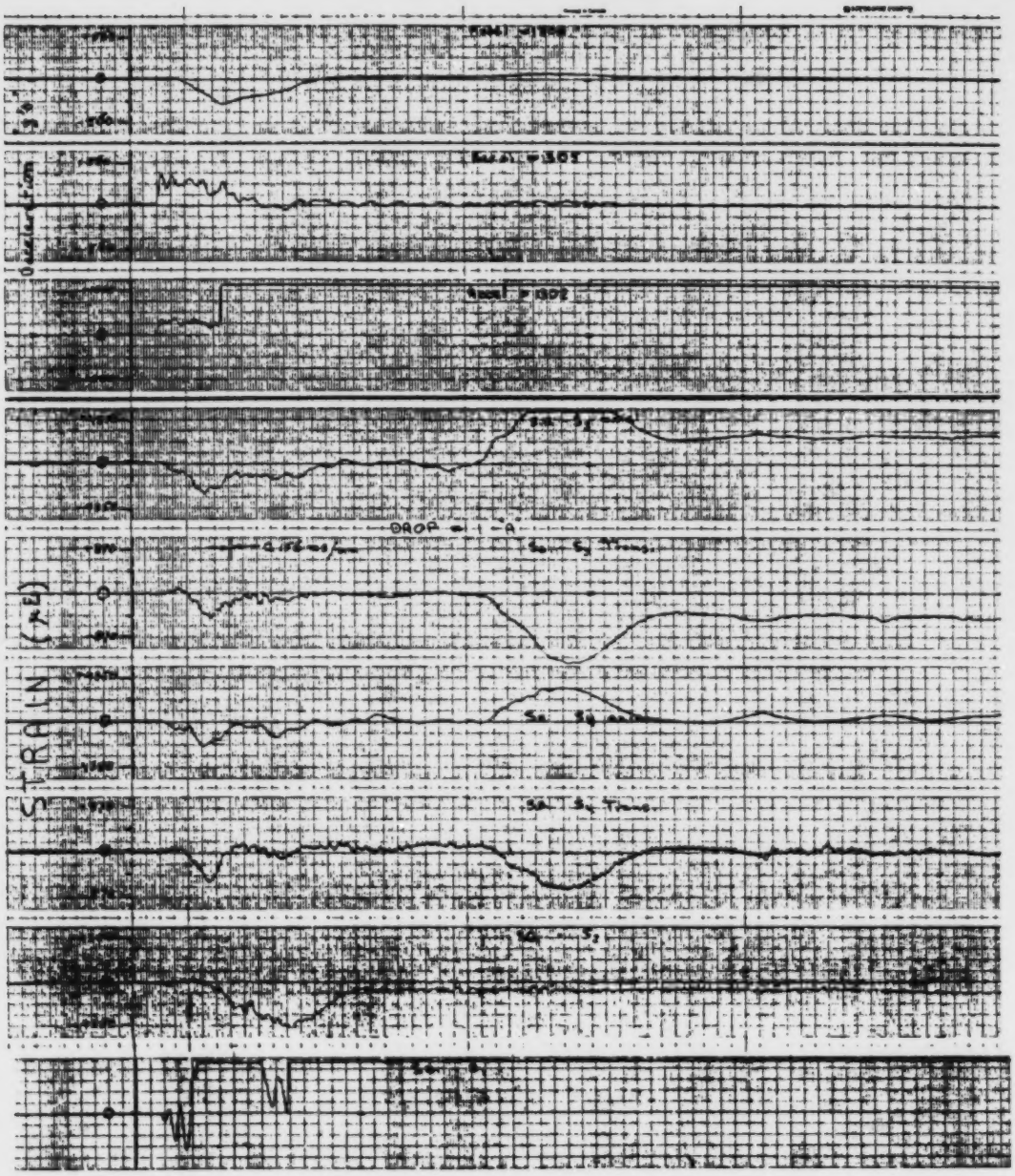


FIGURE 4: Model "A", Bottom Corner Drop (2-A) from 9 Metres

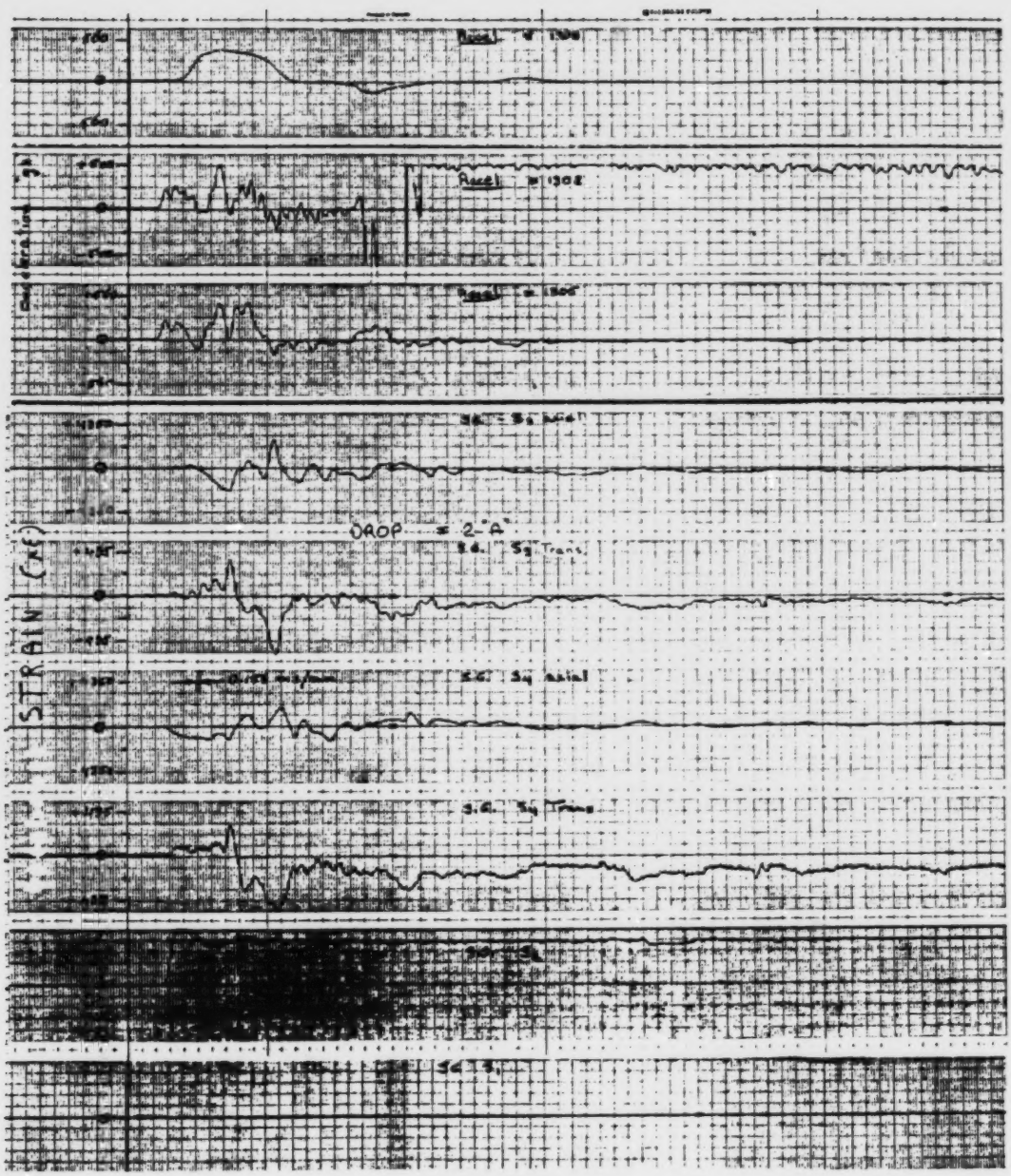


FIGURE 5: Model "A", Side Drop (1-A) from 9 Metres

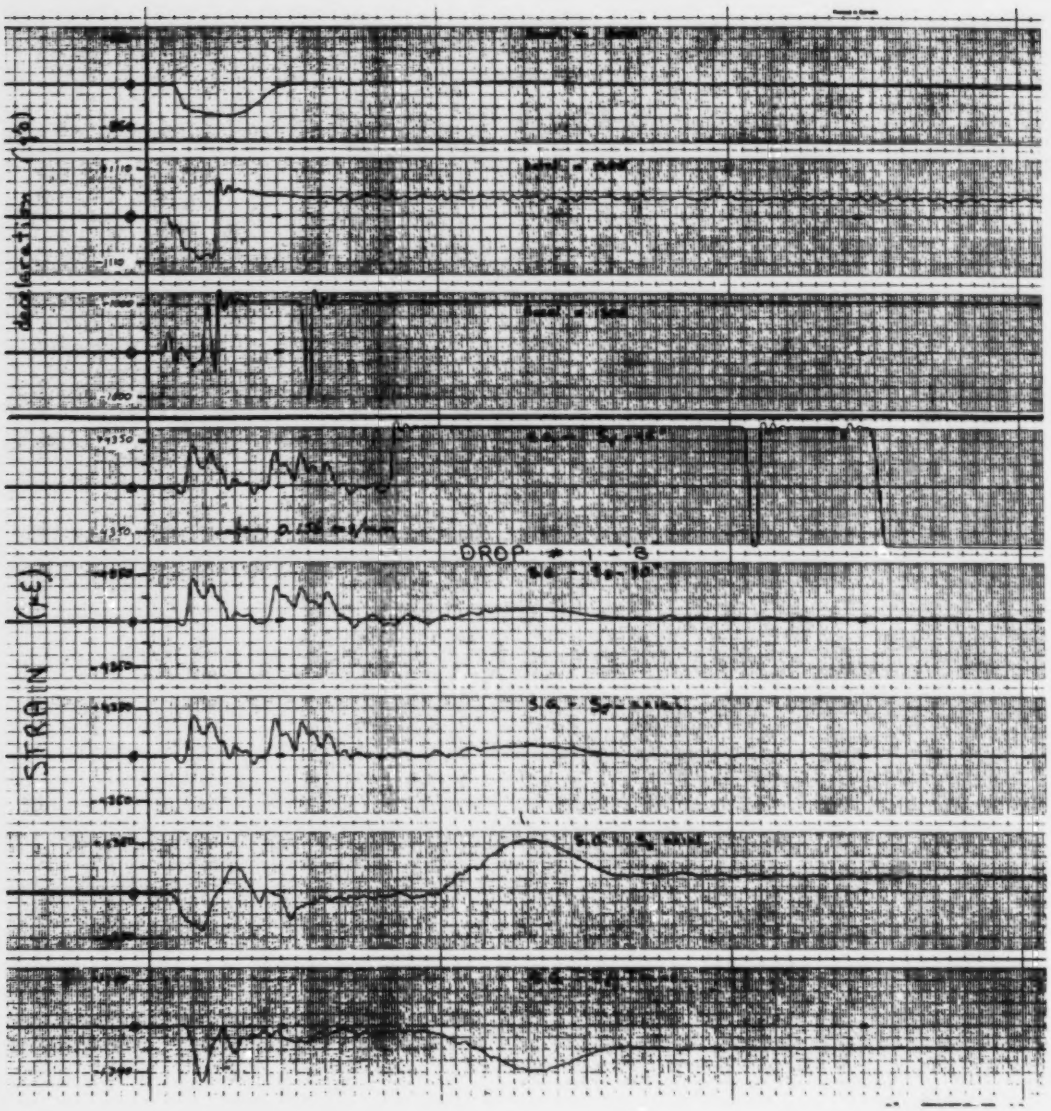


FIGURE 6: Model "B", Flat Bottom Drop (1-B) from 9 Metres

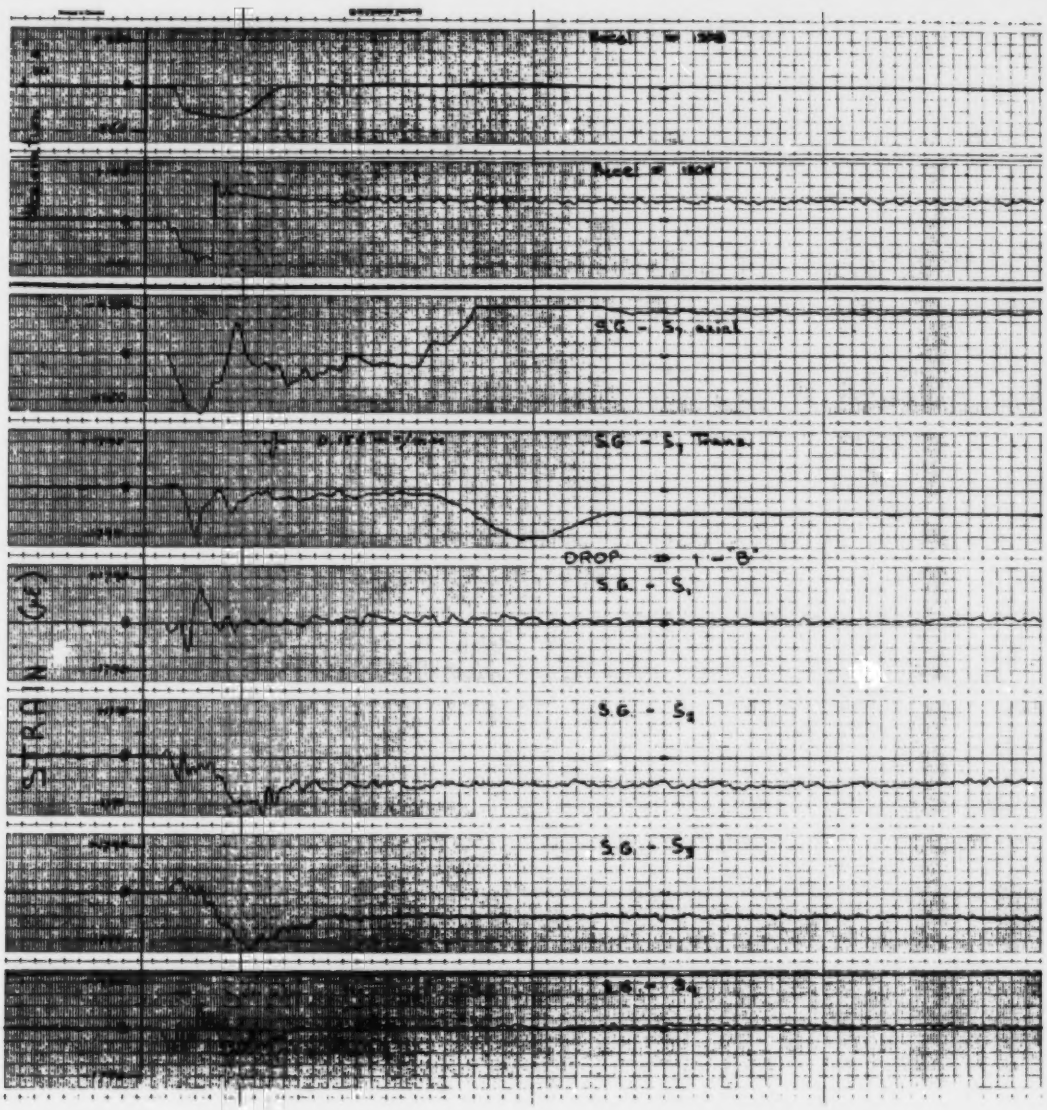


FIGURE 7: Model "B", Flat Bottom Drop (1-B) from 9 Metres (Remaining Transducers)

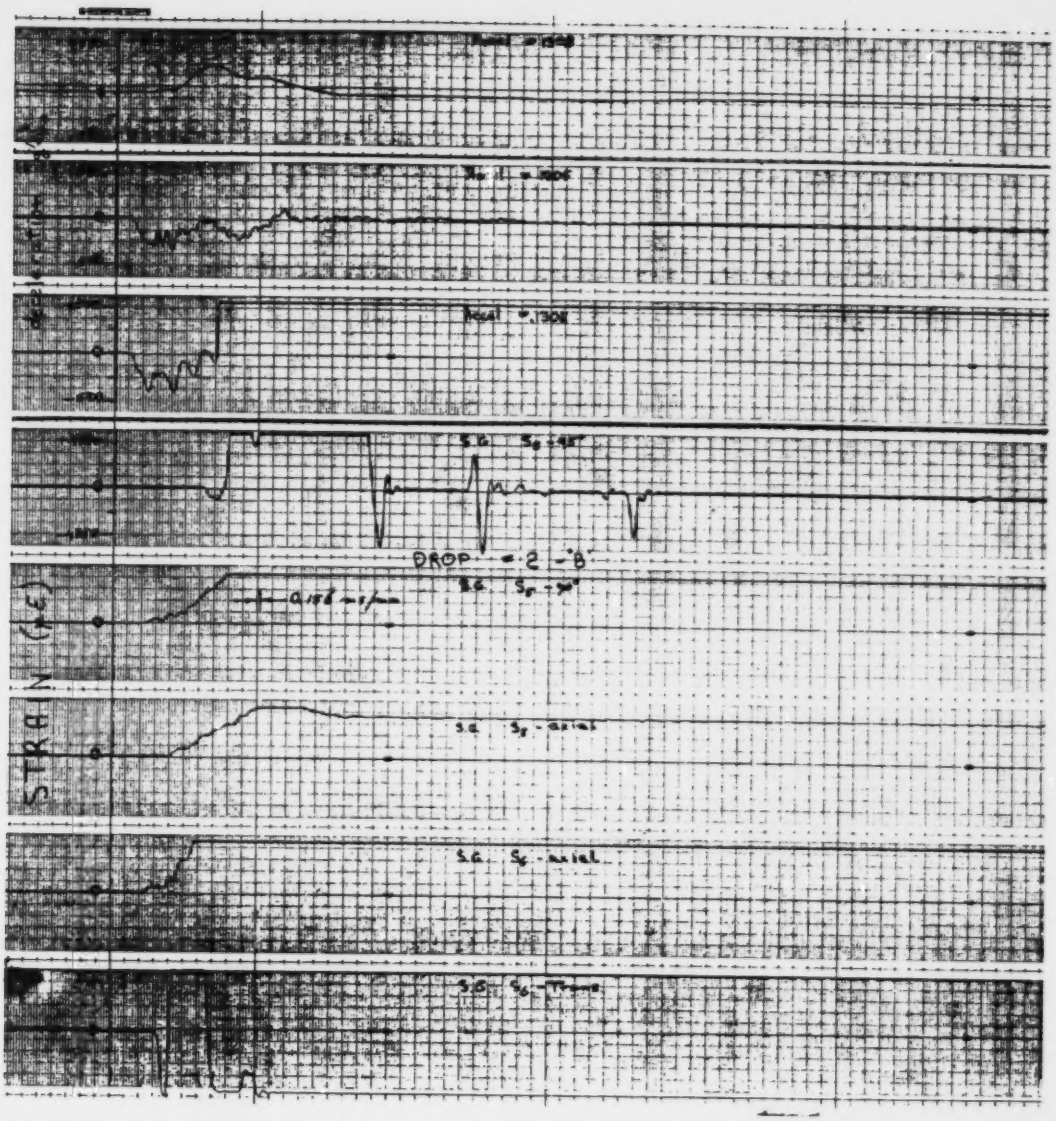


FIGURE 8: Model "B", Top Corner Drop (2-B) from 9 Metres

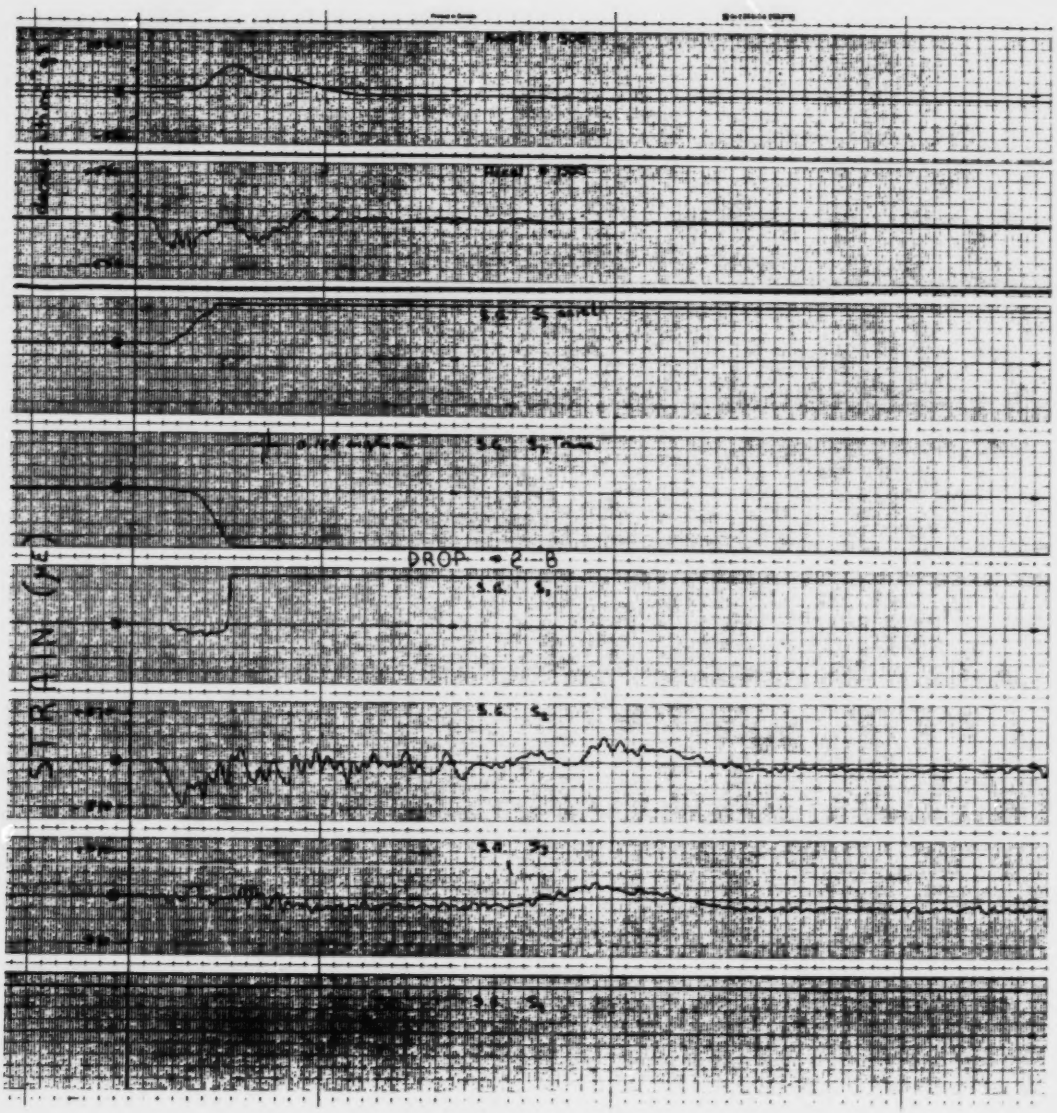
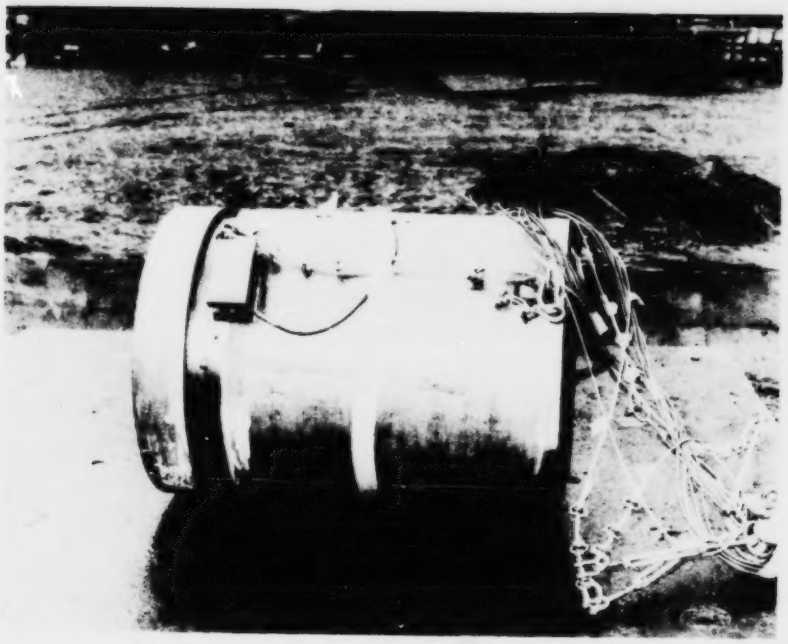
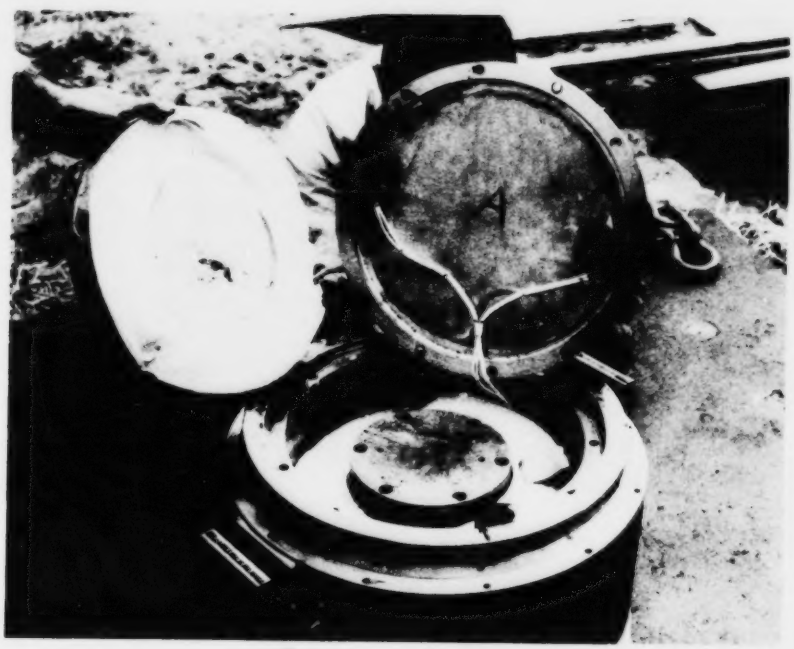


FIGURE 9: Model "B", Top Corner Drop (2-B) from 9 Metres (Remaining Transducers)

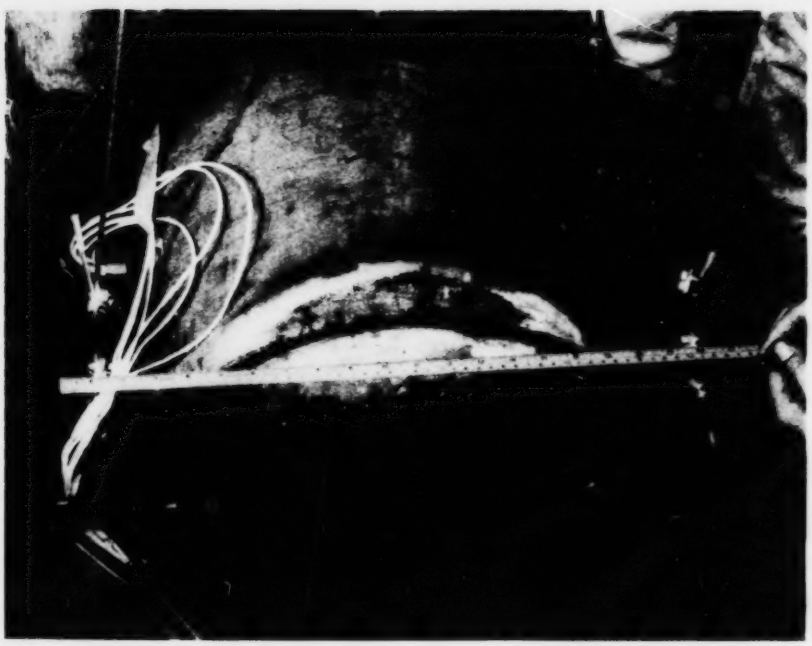
APPENDIX B

Photographs of IFTC Models After Drop Tests

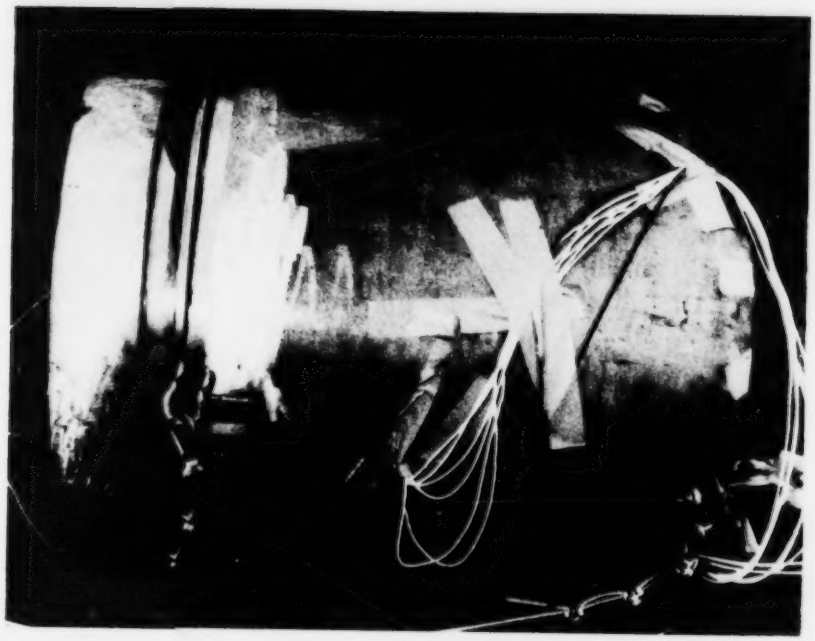




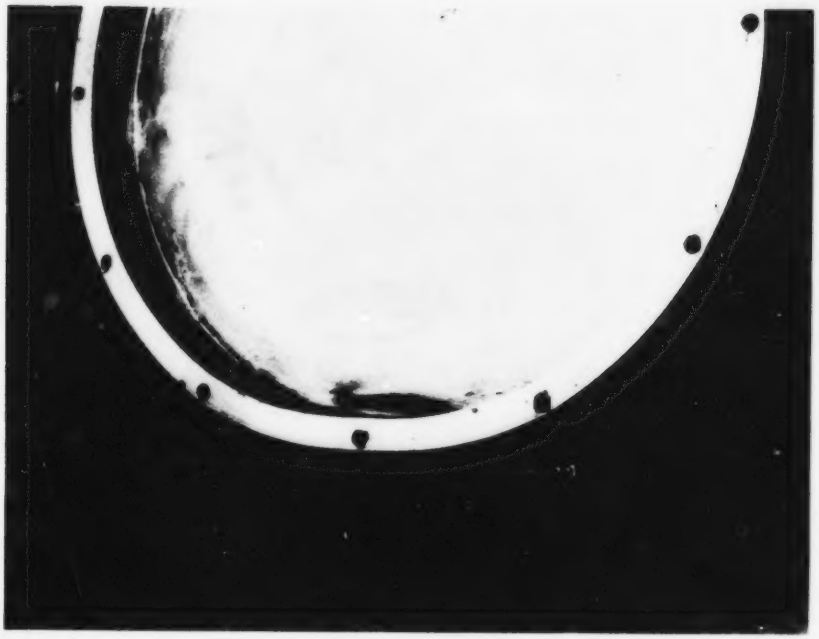
MODEL A - AFTER BOTTOM CORNER DROP

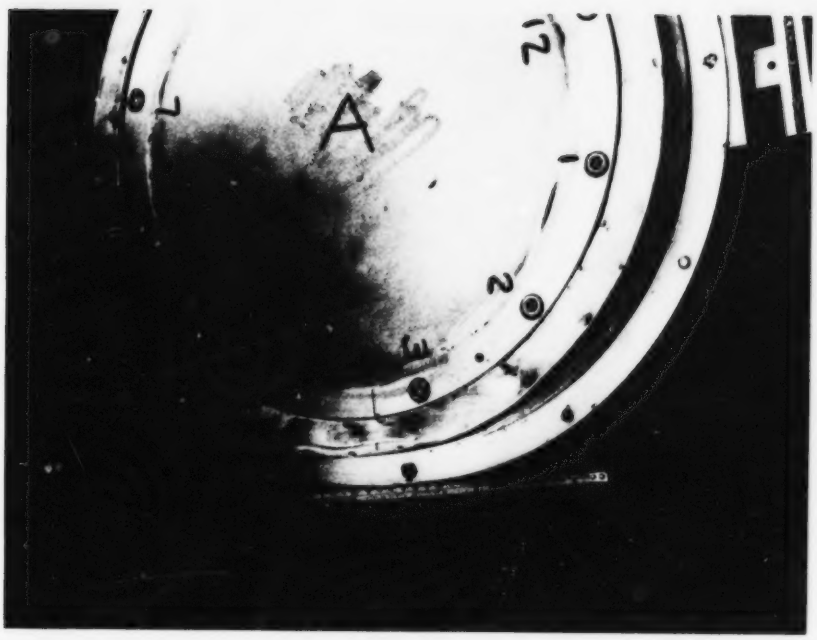


MODEL A - AFTER BOTTOM CORNER DROP

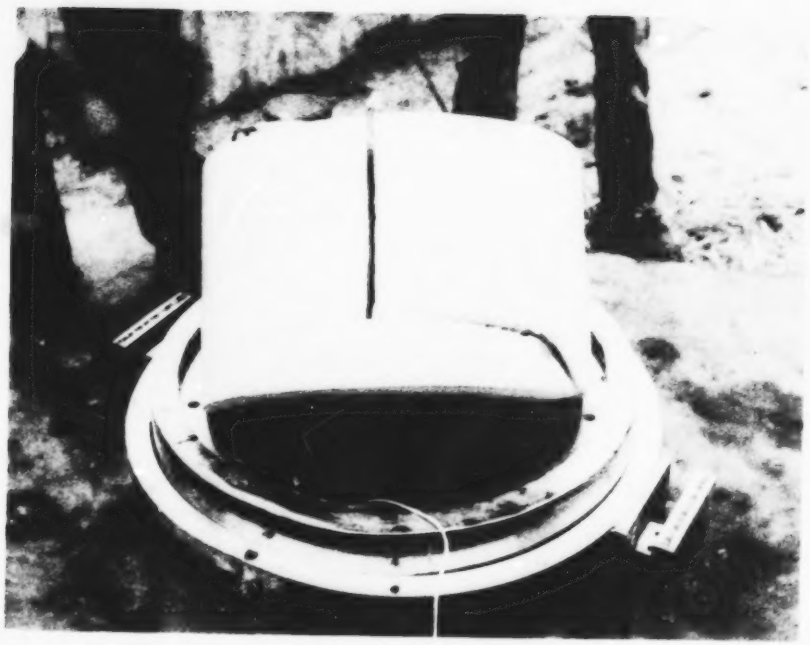


MODEL A - AFTER FLAT SIDE DROP

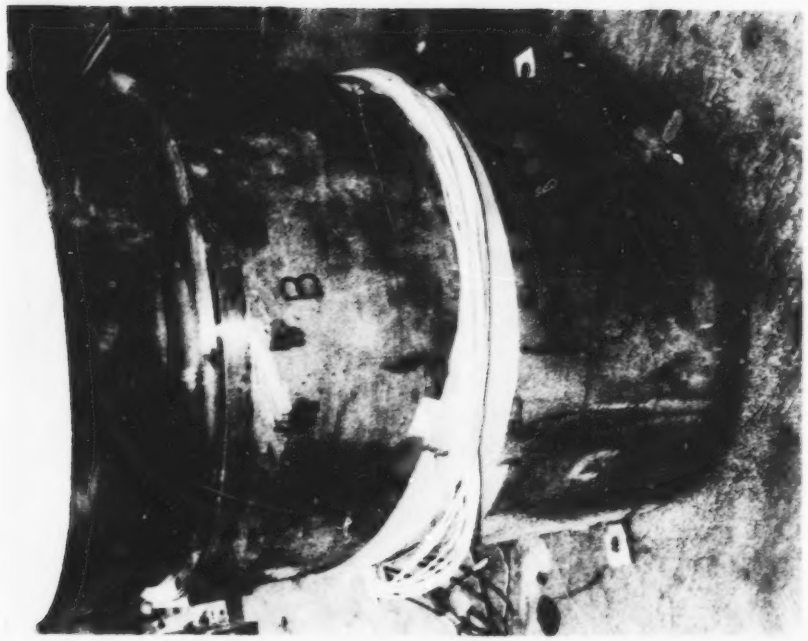


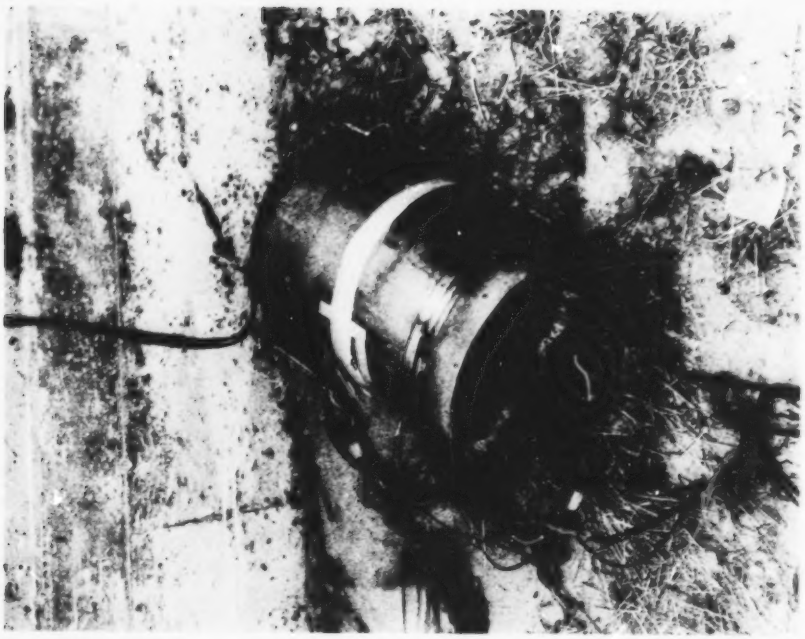


MODEL A- AFTER FLAT SIDE DROP



MODEL A - BOTTOM ENDCAP AFTER FLAT SIDE DROP





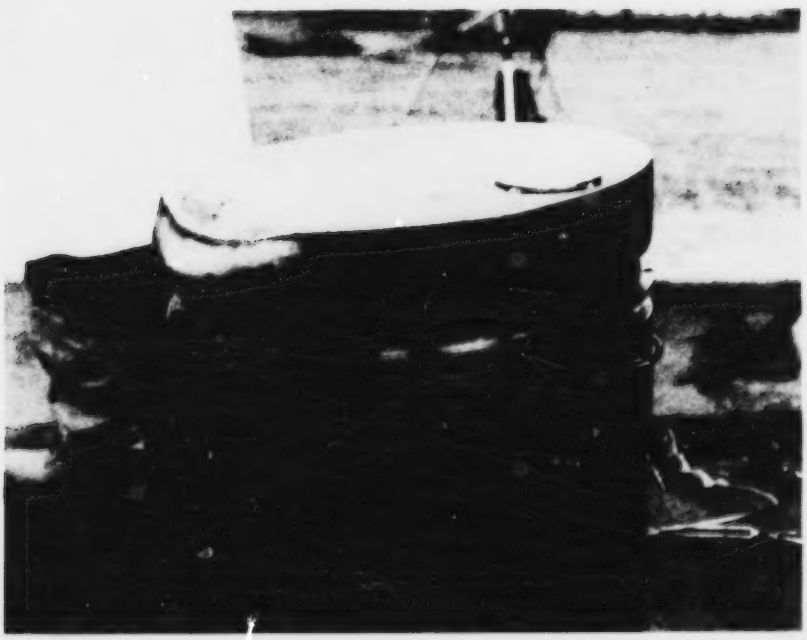
MODEL B - AFTER FLAT BOTTOM DROP

Top Endcap

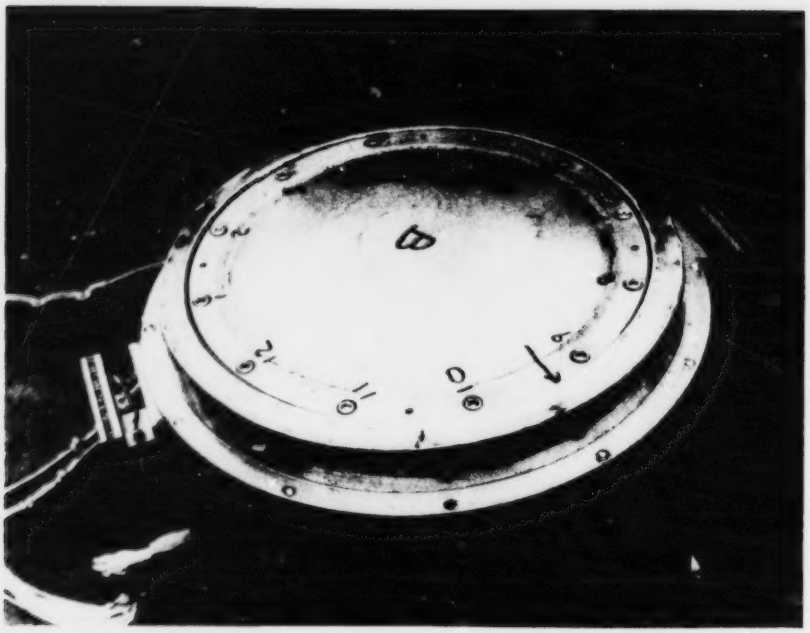
Bottom Endcap

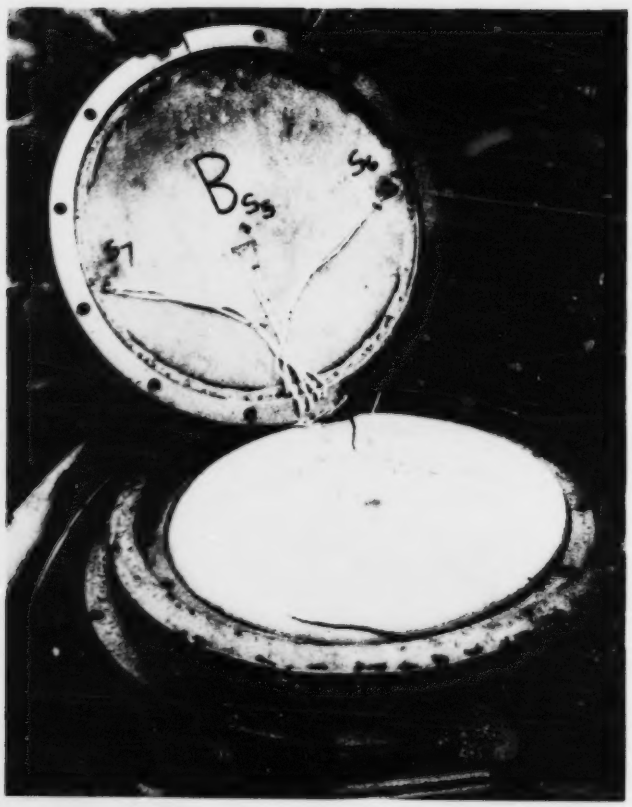
MODEL B - AFTER FLAT BOTTOM DROP

MODEL B - BEFORE TOP CORNER DROP



MODEL B - AFTER TOP CORNER DROP





MODEL B - AFTER TOP CORNER DROP